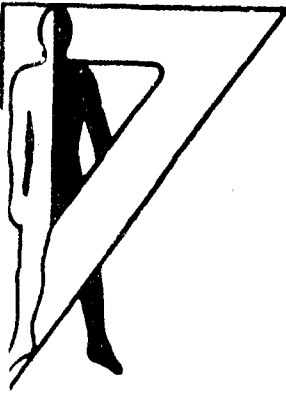


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Technical Note 6-83

WORKSPACE LAYOUT OF AN MB20 VAN
FOR AIR BATTLE MANAGEMENT OPERATIONS

Jon J. Fallesen

May 1983

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The existing Air Battle Management Operations Center (ABMOC), developed by the 9th Division Air Defense Artillery, was evaluated to identify workspace deficiencies. In order to design an improved layout, constraints were identified, design criteria were specified, and equipment was arranged by an iterative process. To achieve the multiple design criteria, the general equipment layout was rotated 90° in the plan view. (Continued)		

The worktable was raised to promote sit/stand operations to provide improved viewing heights. Using recommended viewing angles, a geometrical procedure was used to optimize plotting board angles and viewing distances. Other potential benefits are discussed and illustrated by drawings. This report presents workspace layout analyses and concepts which should be considered to improve the soldier-machine interface.

WORKSPACE LAYOUT OF AN M820 VAN
FOR AIR BATTLE MANAGEMENT OPERATIONS

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May 1983

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WORKSPACE LAYOUT OF AN M820 VAN FOR AIR BATTLE MANAGEMENT OPERATIONS

INTRODUCTION

The Air Battle Management Operations Center (ABMOC) is a component of the Reliable Swift Target Identification and Notification Grid (STING) or Enhanced Manual Short-Range Air Defense Systems (SHORADS) Control System (EMSCS) concept. The ABMOC has the function to consolidate and transmit SHORAD target data. The ABMOC is housed in an M820 expansible shelter and typically is served by eight personnel. The interaction between these soldiers and their equipment is critical for accurate and timely relay of target information. Considering the time critical nature of the man-intensive task and the limitation of space, the workspace of the shelter should have an impact on how the operations are performed. A recommended change to the existing layout (as conceived by 9th Division Air Defense Artillery [DIVADA]) is presented along with the design rationale.

BACKGROUND

Planned doctrine for SHORAD operations is a phased improvement culminating in an automated SHORAD command and control (C²) system. The capabilities of present and upcoming SHORAD weapons will require a sophisticated C² system to support effectiveness. The present doctrine dictates the use of a basic MSCS (US Army Air Defense School, 1981) which modifies previous doctrine primarily by a change in the transmission mode of early warning data. Past doctrine used a radio frequency data link (RFDL) from the forward area alerting radar (FAAR) to a target alert data display set (TADDS) collocated with the weapon system (US Army Air Defense School, 1980). The basic MSCS requires the FAAR operator to transmit target data by voice via an FM radio. A second phase of doctrine, called improved MSCS, to be implemented in FY 83/84, will add improved high frequency radios to increase the reliability and range of transmission (Schock, 1982). The third phase, referred to as EMSCS, takes a significantly different approach whereby sensor track information within the entire division is consolidated and then broadcast over an early warning net to AD fire units. The EMSCS or Reliable STINC concept was developed by the 9th DIVADA (Putman, 1981). The SHORAD Battalion Tactical Operation Center (TOC), or ABMOC, is the activity which consolidates the track information.

OBJECTIVE

The US Army Human Engineering Laboratory (USAHEL) human factors personnel observed operations of the ABMOC during three separate field exercises (Fry & Kurtz, Note 1, Kurtz & Fallesen, Note 2; Kurtz & Smyth, Note 3). During the second visit, the ABMOC operations officer requested that USAHEL address a number of human factors issues, one of which was the task of improving workspace layout of the SHORAD TOC shelter.

TECHNICAL APPROACH

By viewing on-going procedures and reviewing drawings, the existing workspace was assessed. In order to design a layout to improve existing characteristics, the following constraints were defined.

a. The M820 shelter with its associated dimensions and environment would be the physical envelope of the workspace.

b. The size and nature of the plotting boards would be relatively unchanged.¹

c. The type and quantity of radio/communication equipment would be as specified in the ABMOC description (Putman, 1981).

d. The new layout would not significantly alter operating procedures in the ABMOC.

The procedure of layout was then to (1) identify further design criteria, (2) obtain actual equipment and recommended workspace dimensions, and (3) arrange the equipment to fulfill the multiple criteria. The layout process was an iterative one characterized by repetitions of layout drawings, construction of a full-scale static mock-up, and subsequent drawing modifications for a recommended new layout.

EXISTING ABMOC SHELTER

The ABMOC shelter developed by the 9th DIVADA consists of an M820 5-ton expansible van (Figure 1) with plotting boards, communications, and other equipment. A top view of the existing layout is presented in Figure 2.

A brief description of the functions which take place in the ABMOC is necessary to better understand the nature of the workspace. There are three plotting boards having complimentary purposes. The long range plotting

¹The plotting boards used in layout considerations were those designed and fabricated by USAHEL. These boards are adaptations of existing boards used by the 9th DIVADA. The boards were built for use by USAHEL in related projects. (See Appendix A.)

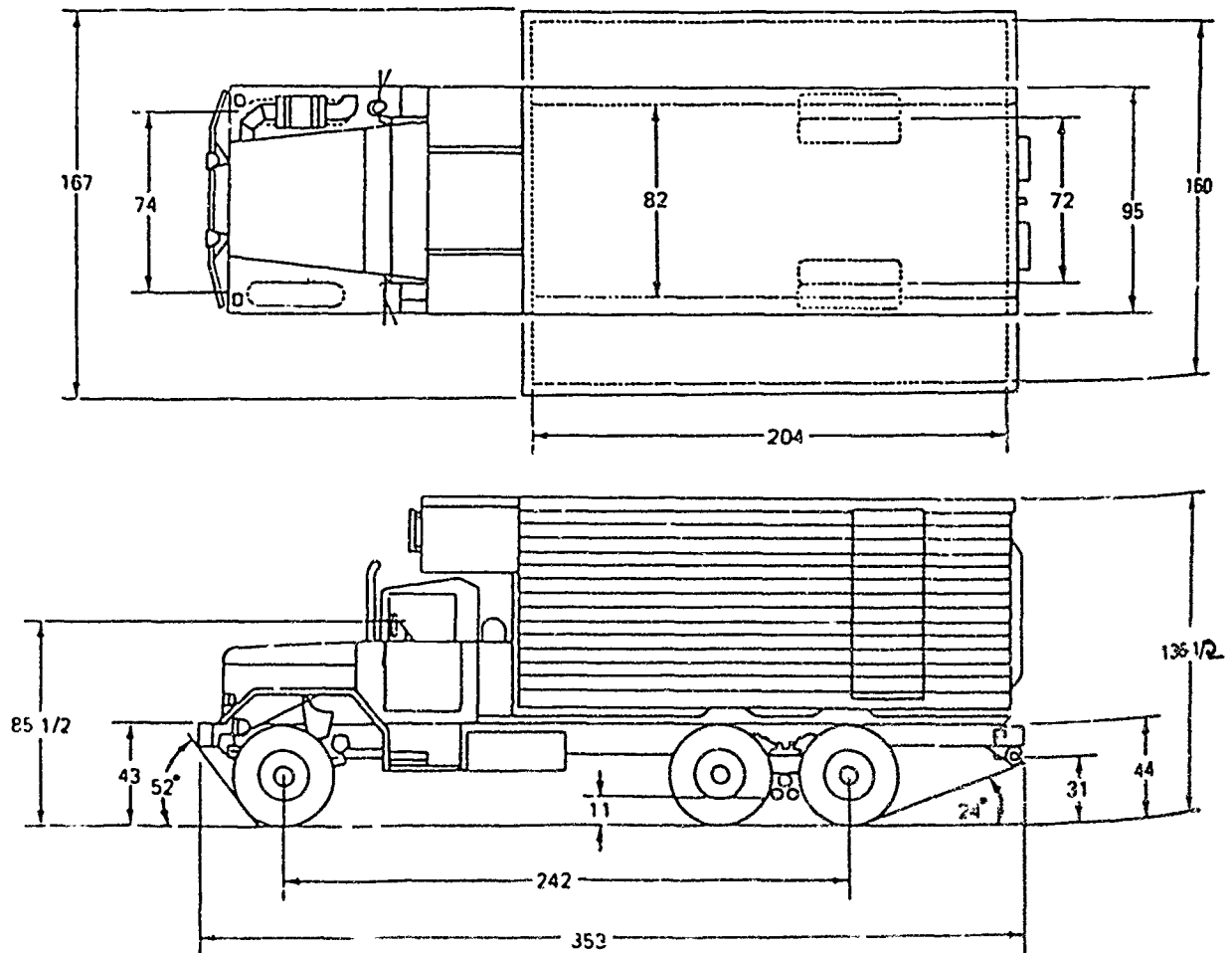
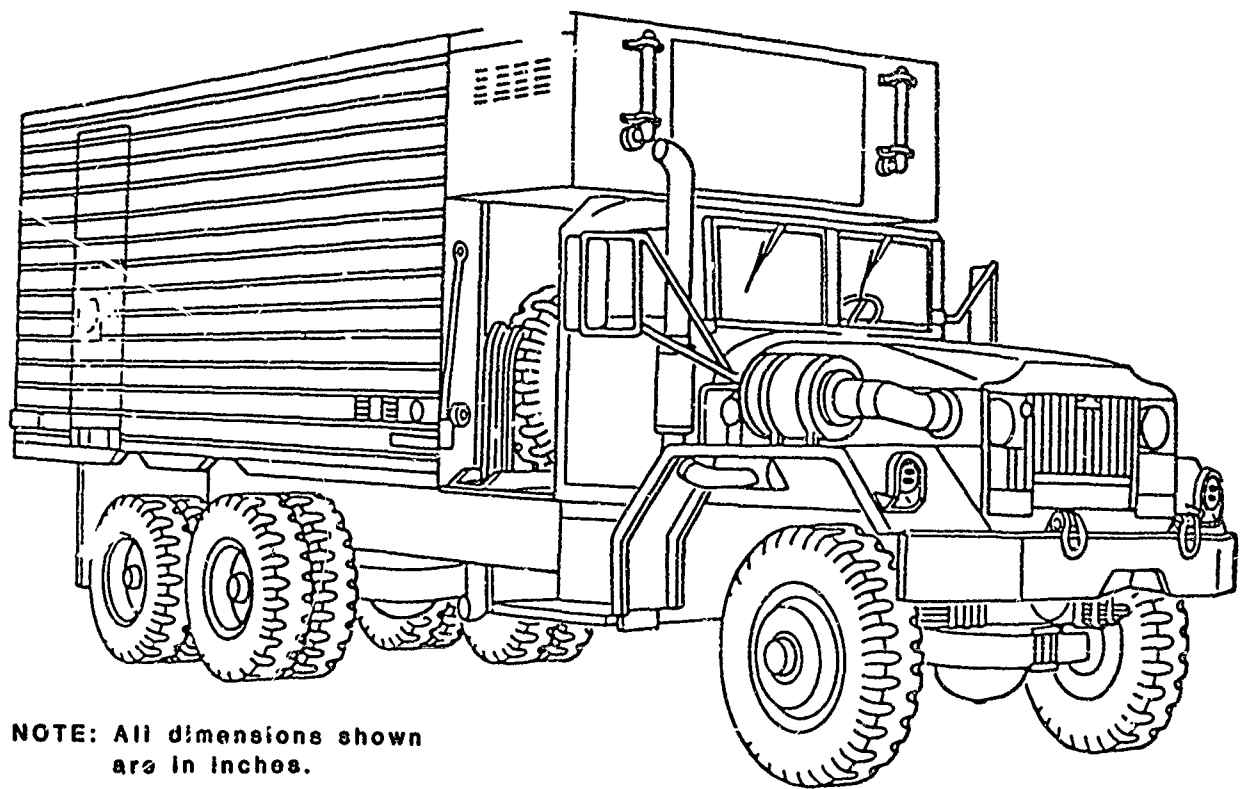
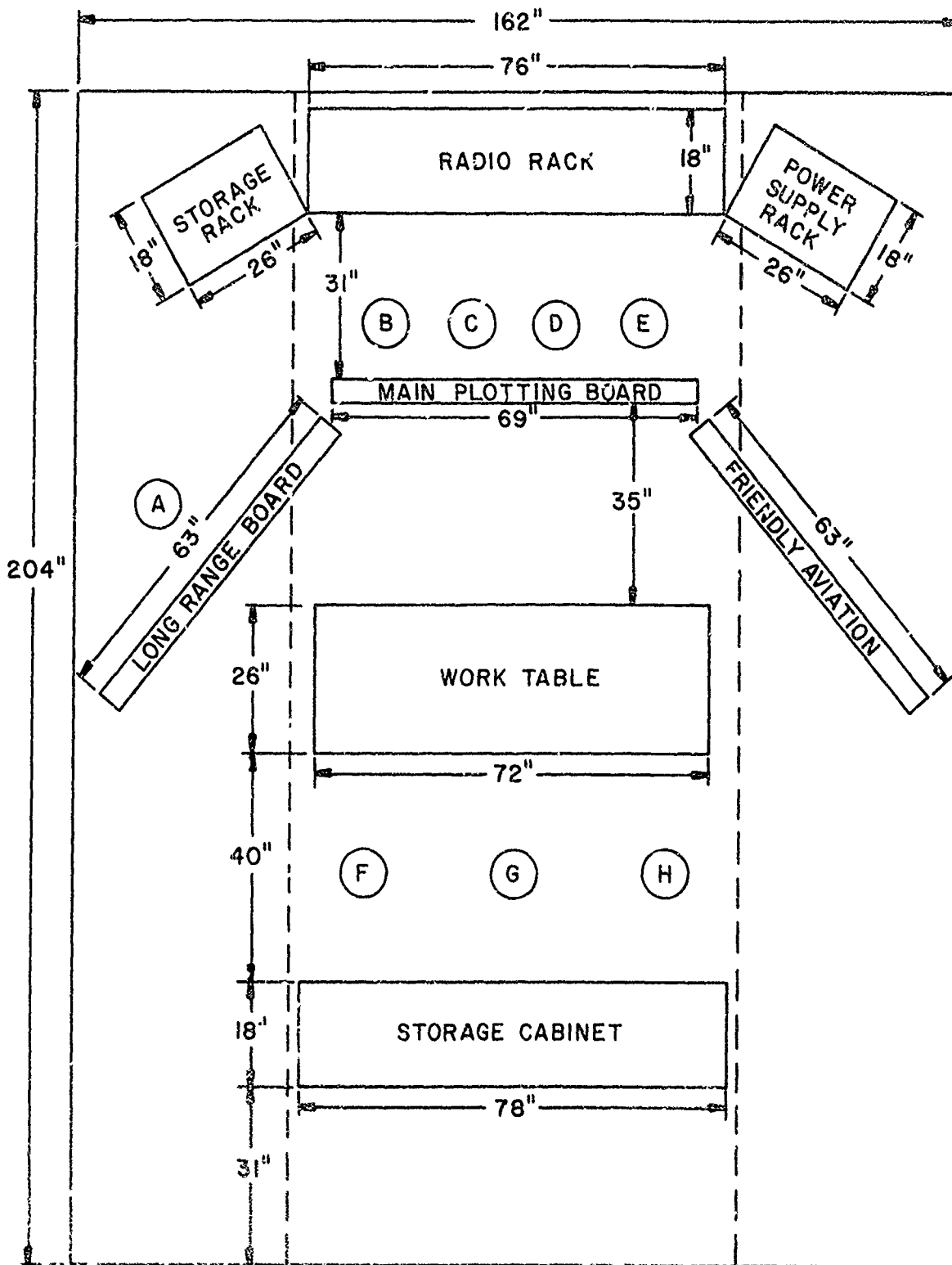


Figure 1. M820 5-ton expansible van.



Note: Personnel are located at the circles (A-HIMAD plotter; B, C, D, E - FAAR plotters; F-OIC; G-RTO and H-aviation operations specialist).

Fig. 2. Existing layout of the Air Battle Management Operations Center (ABMOC).

board is maintained by a plotter monitoring a high-to-medium altitude air defense (HIMAD) source of radar track data. The board is scaled to 1:100,000 for an area of 180 km x 180 km. A main plotting board is centered among the three boards with a scale of 1:50,000 for an approximate division area of 80 km x 70 km. This board is maintained by four plotters. Each plotter monitors a separate FAAR transmission, and then plots the required information (viz. target identification, location, type, and heading). A friendly plotting board with the same characteristics as the main board is used for airspace management data which is maintained by an aviation operations specialist. The Division Air Management Element (DAME) supplies these data consisting of friendly aviation plans, route structures, identification procedures, avenues of approach, hostile air action, etc.

The plotting is done on one side of the fluorescent edge lit plexiglass boards and read from the other. Plotting of heading and alphanumeric characters is done in mirror image to produce the proper orientation when read from the other side. Each board is marked in a SHORAD grid system (Army Air Defense School, 1981; Fallesen, 1983) which consists of 400 grid names with a code word assigned to each square of 10 km x 10 km. Each 10 km area is further divided into 1 km increments.

The information of the three plotting boards is consolidated into a composite "air picture" and broadcast on the division air defense early warning net (DADEW). The net is implemented by transmitting AM and FM radio signals. The radio telephone operator (RTO) is primarily responsible for broadcasting track information. The officer-in-charge (OIC) assists by directing and prioritizing information as well as controlling the FAAR plotters.

By considering these operations and the associated equipment layout, several deficiencies were identified.

a. Nonoptimal viewing angles of plotting boards for the OIC, teller, and the aviation operations specialist exist. The viewing angles for the main plotting board are less than optimal due to the normal height of the eye in the present configuration. The center line of optimal eye rotation (Van Cott and Kinkade, 1972) for seated 5th and 95th male military personnel is extrapolated to the plotting board in Figure 3.

b. The indicator lights from the access panels of the radios create visual distraction. Color grease pencils or ink markers appear to have a "lit" appearance when a character is plotted on the board. This is a very good highlight technique, however, the radio lights also appear through the boards. Since the lights are brighter than the grease pencils, the lights have a higher "attention-getting" quality.

c. Access to radios by primary controllers (OIC, RTO, and aviation operations specialist) is limited to voice interaction with the plotters close to the radios. The OIC, RTO, and aviation operations specialist are primary controllers of the radios due to task responsibilities. Since the location of the radios is not presently near these three, voice instructions are called to the plotters. (A possible alternative is for remote frequency changing.) Maintenance of the radios would require additional personnel to share the same workspace as the cluster of FAAR plotters.

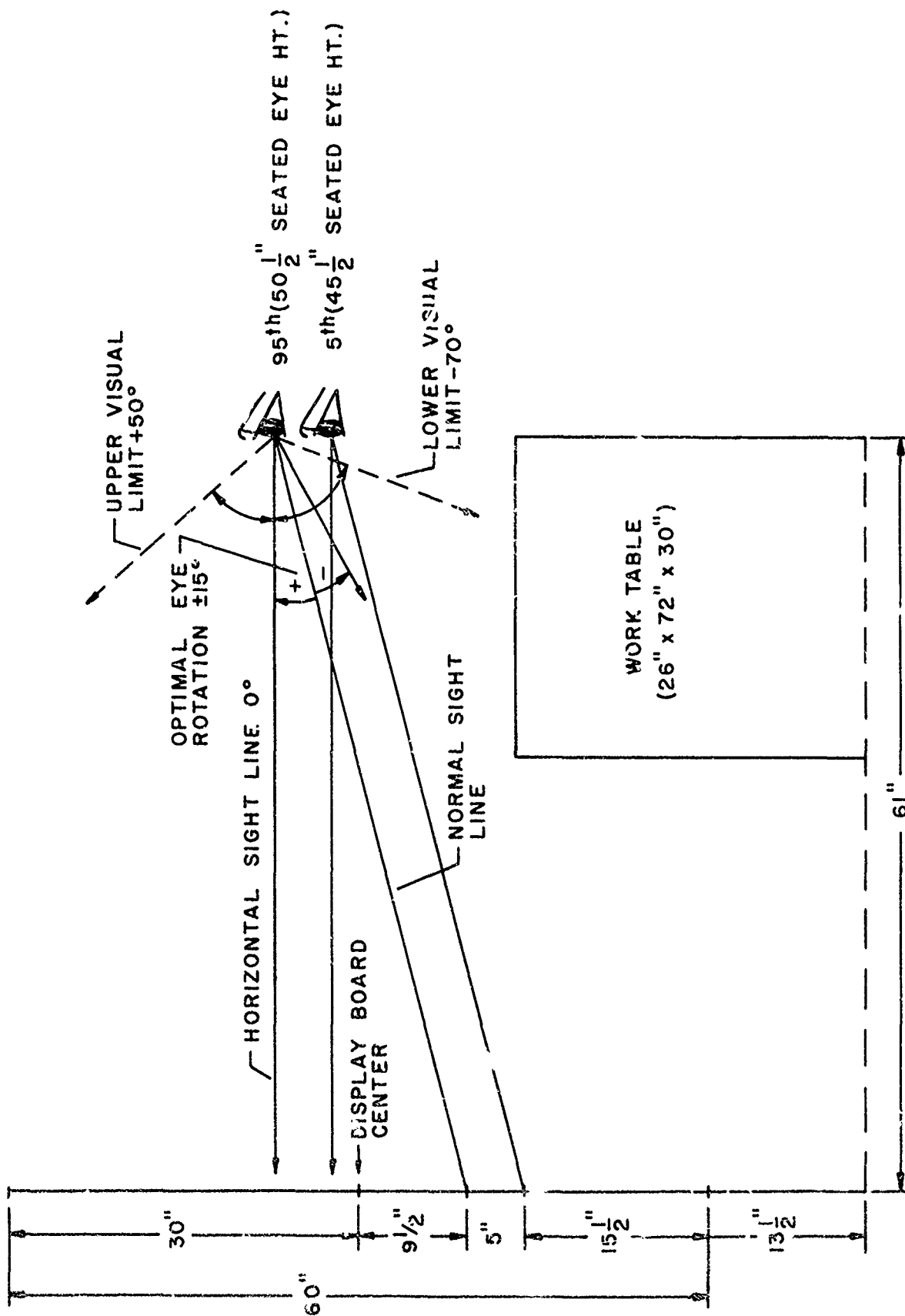


Figure 3. Normal sight lines for 5th and 95th percentile seated male military personnel for the existing ABMOC configuration.

d. Workspace and passage area are insufficient for the plotters. There is limited workspace for squatting operation by the plotter when passage behind is also required. Woodson (1981) recommends a 36" minimum for squatting operations and Thomson (1972) recommends a 36" width for one person standing and one person passing (perpendicular) with a 30" minimum. At the two side boards, the workspace problem is compounded where the boards are near the sides of the van.

e. Ingress/egress for the plotters to and from their stations is inadequate. Either side board (they are hinged to the center board) must be moved aside for access to plotting stations. This can create plotting problems if the board is in use at the time. It does not allow for fast exit/entrance as boards are normally secured in place by a spring loaded lever. It is possible to have six plotters (and possibly other personnel) behind the boards at one time. If the need for emergency egress arose, the obstacle of the boards and the distance to the exit could be critical factors.

MODIFIED LAYOUT AND RATIONALE

In addition to the design constraints on page and the preceding list of deficiencies, the layout was modified to obtain the following design objectives:

a. Improve viewing by the OIC, RTO, and the aviation operations specialist to include optimizing viewing distance, height, angle, and minimizing visual distraction.

b. Allow for sit/stand operation by the OIC, RTO, and the aviation operations specialist.

c. Allow proper ingress/egress to/from stations by all occupants of the van.

d. Provide recommended workspace/passageway dimensions.

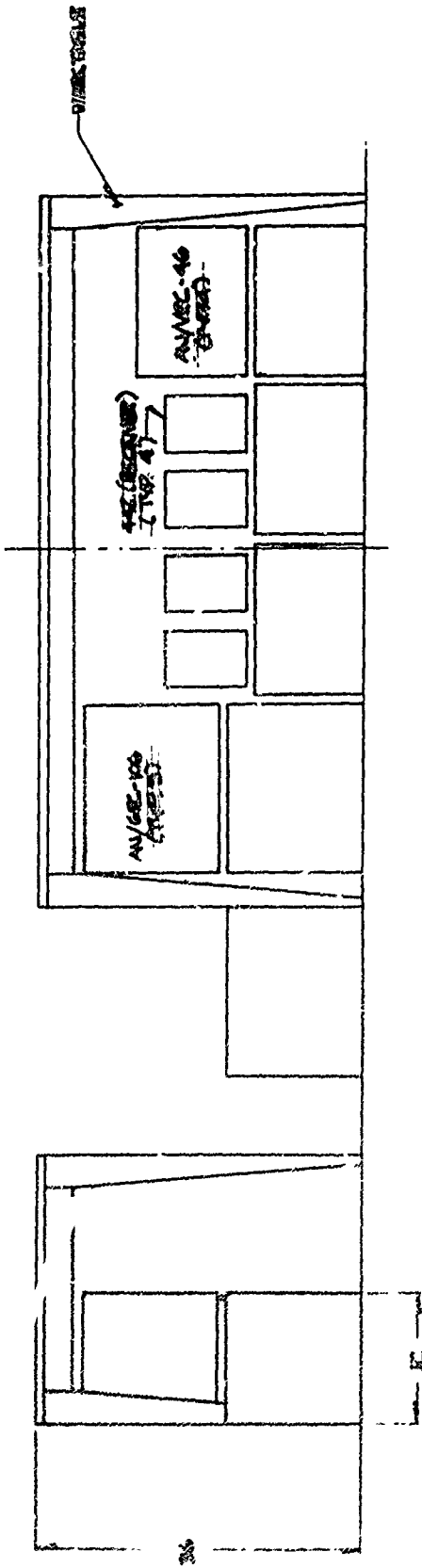
e. Be responsive to anthropometric dimension of Army personnel.

f. Provide storage space for individual soldier's equipment.

In order to achieve three of these criteria simultaneously (viz. provide recommended workspace dimensions, ingress/egress, and optimize viewing angles), the primary change was to turn the orientation of plotting boards and the worktable 90° (Figure 4). The worktable was raised to a height of 36" to promote sit/stand operation, allow for increased storage space beneath and to raise the OIC, RTO, and the aviation operations specialist to an improved viewing height (Figure 5).



Figure 4a. Modified top view layout of the Air Battle Management Operations Center.



SECTION A-A

Figure 4b. Side and front view of Option #1 (i.e. radios placed beneath worktable).

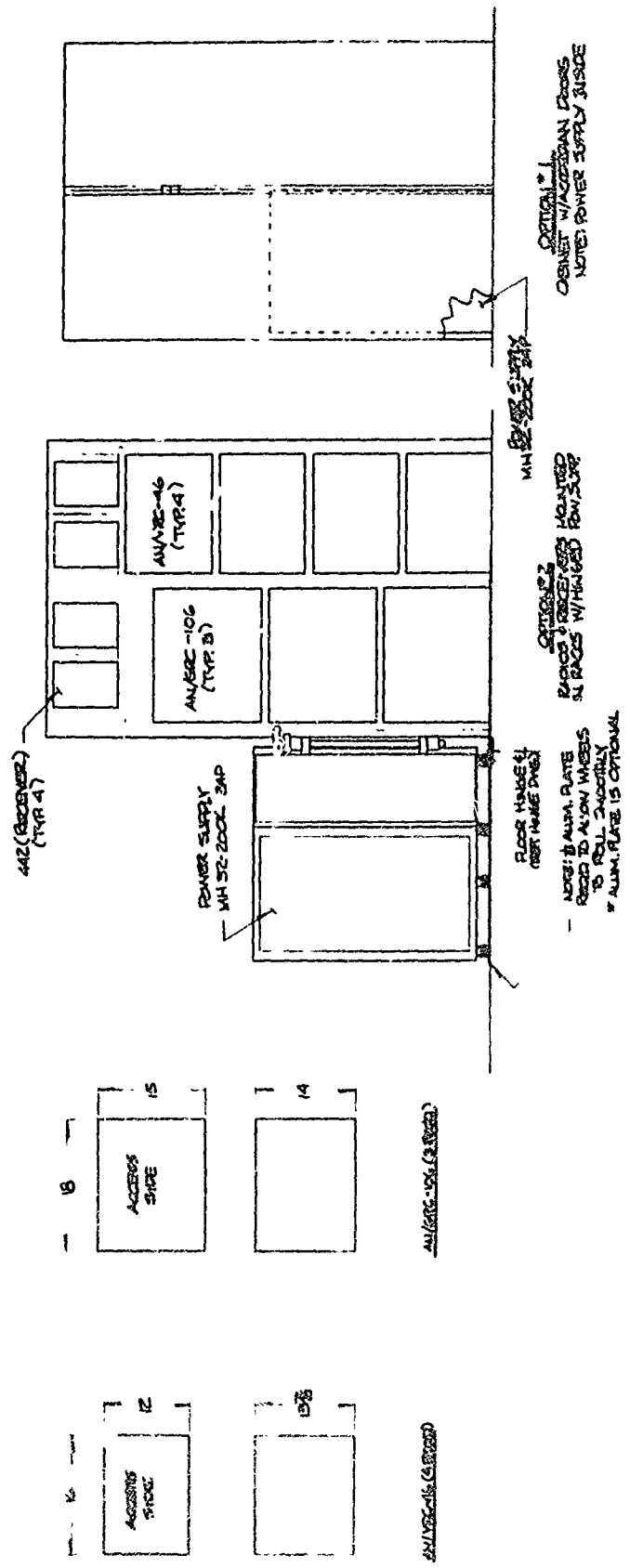


Figure 4c. Dimensions of radios and front view of storage shelves and power supply. Option #2 show radios placed in the storage shelf.

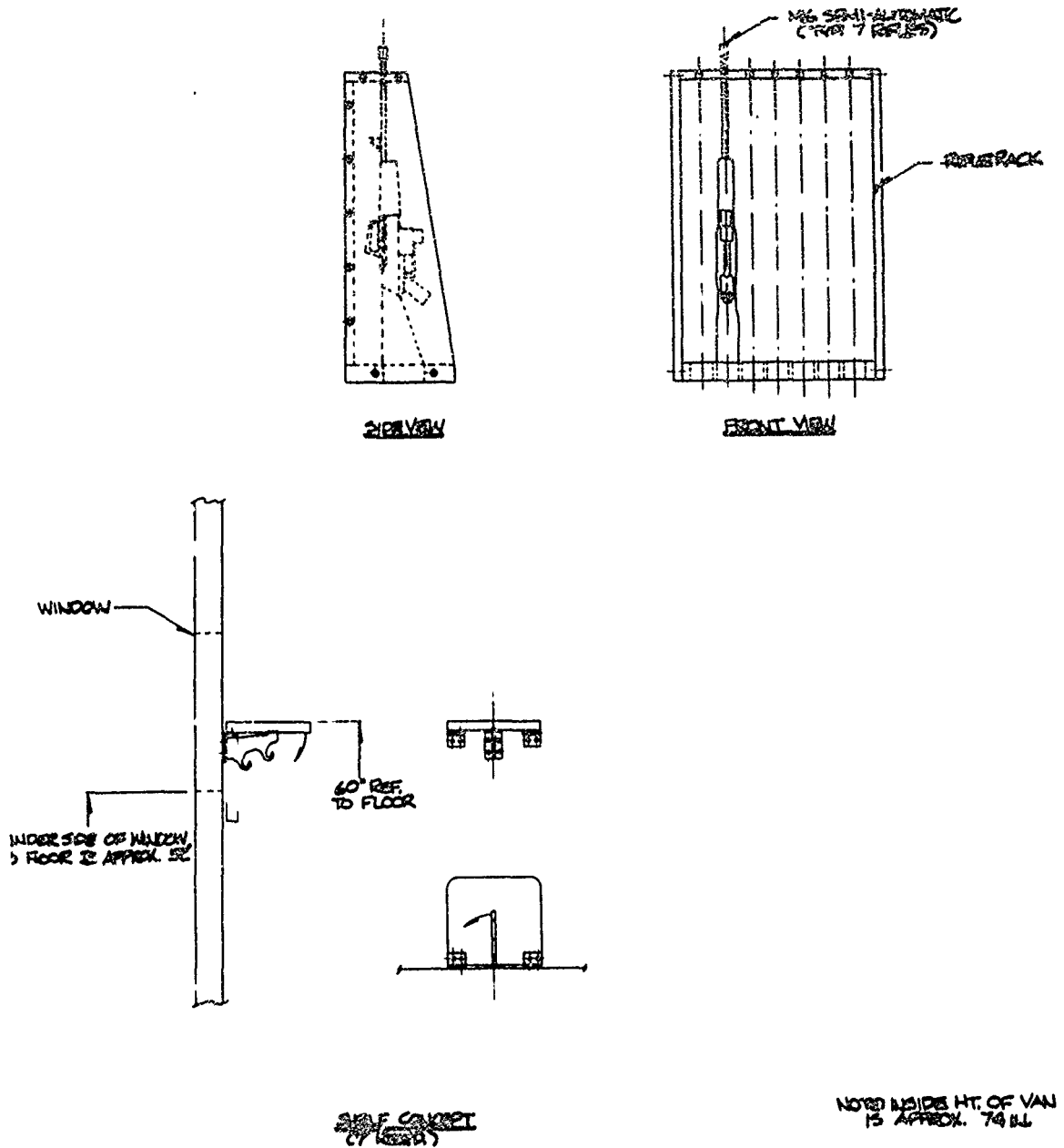


Figure 4d. Rifle rack and shelf for soldier's gear.

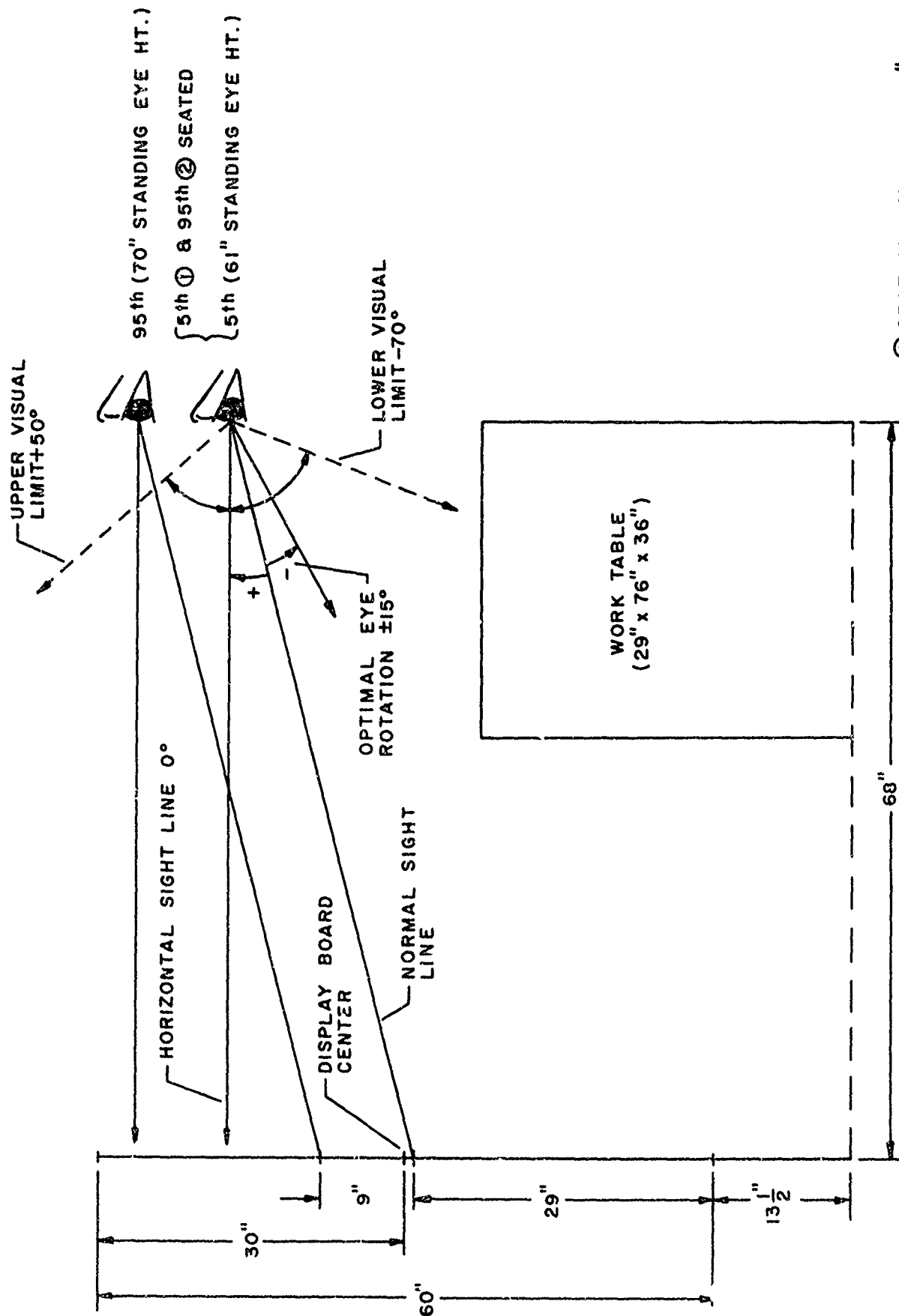


Figure 5. Normal sight lines for 5th and 95th percentile seated and standing male military personnel for the modified ABMOC configuration.

① SEAT ADJUSTED TO 32" HT.
 ② SEAT ADJUSTED TO 27" HT. UP TO 32" HT.

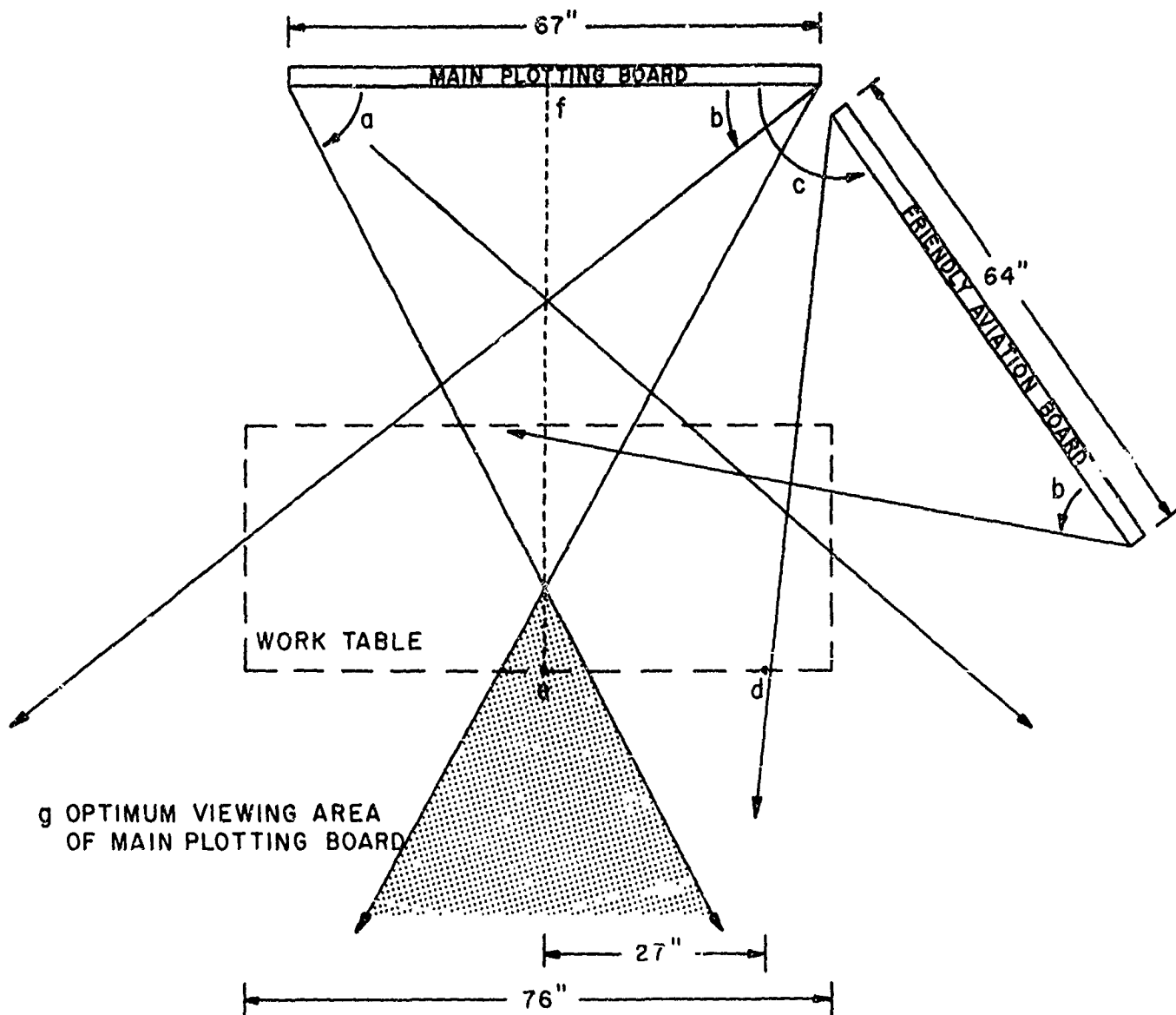
Assuming that the shortest viewing distance would be a horizontal line from the eye (defined to be located at the curb side of the table) to the main plotting board, this distance was optimally set at 68 inches. Figure 6 illustrates that this distance is optimal and how the angle of the side boards to the main board was determined to achieve an optimal 60° viewing angle for the RTO when viewing the main plotting board and a minimum 45° viewing angle for the OIC and aviation operations specialist for all boards.

The positioning of these boards allows a recommended minimum aisle width of 20" between the front end of the van and the friendly board and the back end of the van and the long range board. Ingress/egress is improved by having sufficient passageway and having fixed position boards and worktable, which will not need to be moved when the expansible sides of the van are collapsed for march order.

Two alternative layouts for location of the radios is provided. One option places the radios beneath the worktable, so the OIC, RTO, and the aviation operations specialist have direct access. The radio indicator lights do not pose any interference in this position since they are shielded by the table top. A recommended minimum dimension of 16" was retained for knee space in front of the radios (VanCott & Kinkade, 1972). The second option locates the radios in a storage rack at the front end of the shelter. A condensed layout as compared to the existing scheme was used to conserve space. Since the friendly aviation board is the most infrequently used for plotting, maintenance would not pose much of an interference problem. Radio control such as frequency changing may be a problem. Remote frequency changing equipment could be interfaced to the radios and located on or near the worktable.

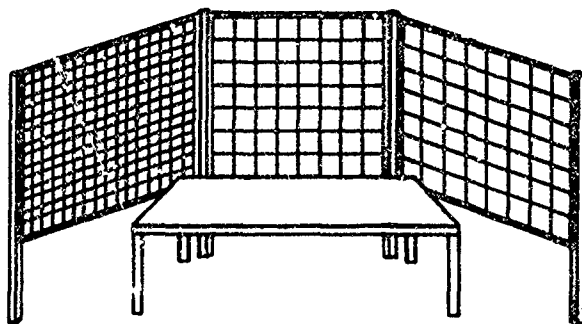
To obtain exact dimensions of a power supply ERADCOM was tasked with determining a suitable power supply and providing dimensions (Groehl, Note 4). Option 1 displays the power supply within the storage cabinet, and for option 2 it is in a hinged arrangement on the side of the storage cabinet (Figures 4b and 4c). Cabling for the radios can be located from the cabinet/power supply across both of the plotting board standards, dropped to the floor and run across the floor to the worktable.

To support sit/stand operations a raised worktable (36" high) is provided with adjustable (27-32" seat height) swivel stools. Figure 7 illustrates the portion of the boards which can be seen for 5th and 95th male military personnel at stationary viewpoints. The 61" eye height represents the nominal height for (a) 5th percentile male Army personnel when standing, (b) 5th percentile male Army personnel when seated (seat adjusted to 32" height), and (c) 9th percentile male Army personnel when seated (seat adjusted to 27" height). The 70" eye height represents the nominal height for 9th male Army personnel when standing. Those portions not seen are because of the interference of the roadside table corners. The viewable areas are as measured from fixed points in the static full scale mock-up. All observers are provided with full viewing of the main plotting board at seated and standing heights. The nonviewable areas can be compensated by nominal head movement.

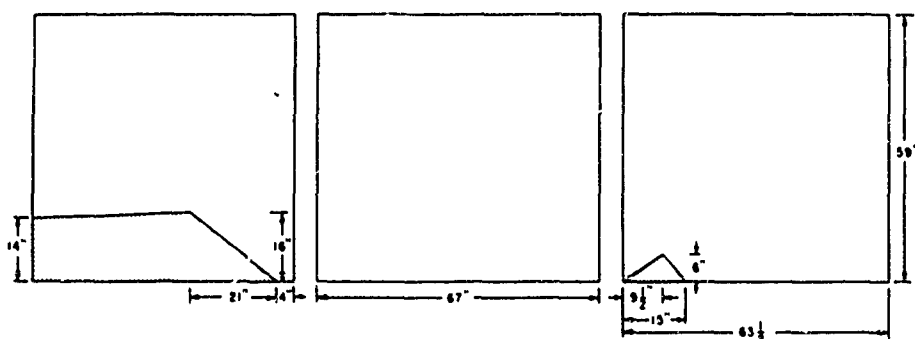


Note: Angle $a = 60^\circ$ (optimum viewing angle).
 Angle $b = 45^\circ$ (minimum view angle).
 Point d is the observation center position for the aviation operating specialist.
 Point e is the observation center position for the RT0.
 Angle $c = 125^\circ$ and line $ef = 68"$ (determined simultaneously such that point d would lie within the minimum viewing area of the friendly aviation board and point e would lie in area g).

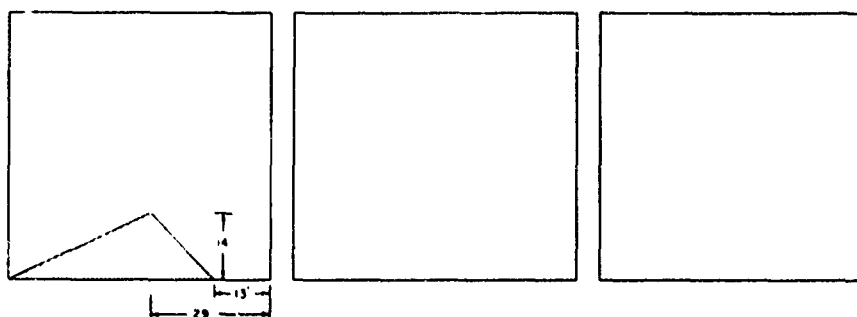
Figure 6. Representation of optimum viewing distance (e to f) and board to board angle (c).



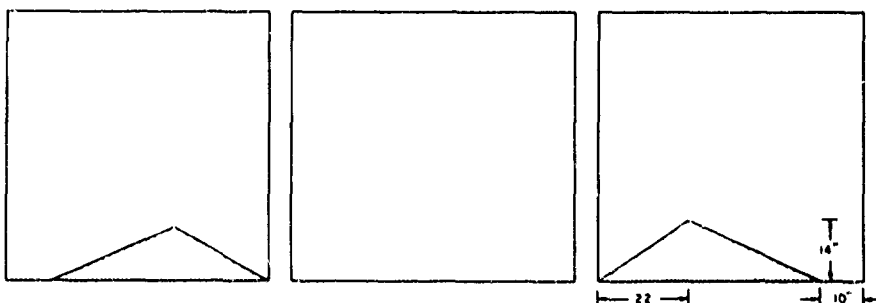
Perspective of
worktable and
plotting boards.



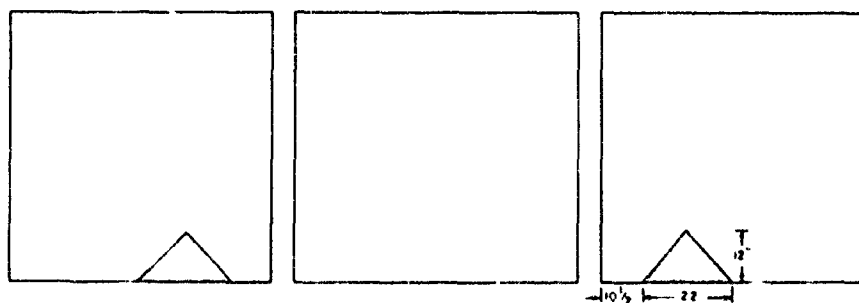
Right side viewing
61" eye height.



Right side viewing
70" eye height.



Center viewing
61" eye height.



Center viewing
70" eye height.

Figure 7. Plotting board occlusion areas due to worktable visual interference from two viewing positions and for two eye heights.

An itemized list of personal equipment and gear was used to design individual storage space (Table 1). An M16 rifle rack is provided in immediate proximity to the van opening. By storing the rifles in this location there is positive, secure placement and less chance of scratching the plexiglass boards. Collapsible storage shelves have been provided for holding personal gear. When the sides of the expansible van are to be collapsed, the hook is swung to the side and the shelf folds flat against the side wall.

TABLE 1

Equipment List for ABMOC Personnel

Helmet

Belt

Suspenders

Canteen

First Aid Pouch

Ammunition Pouch (2)

Protective Mask

Field Jacket

Poncho

Rain Gear

M16 (.45 caliber pistol)

(Leonard, Note 5)

CONCLUSIONS AND RECOMMENDATIONS

The modified workspace layout (shown in Figures 4 and 8) provides a design which alleviates the cited deficiencies and optimizes the criteria within the given constraints. There are considerations to the present layout which have not been depicted in any figures.

Blackout curtains could be added to the layout around one door of the entrance without interfering with workspace around the long range board. Also, the modified layout has reduced storage space for ABMOC supplies, such as maps, wire, markers, etc.; however, additional storage could be added. This would probably be achieved by using cabinets or racks which slide or pivot (as does the power supply) to the unused corners of the van. With the given constraint of plotting board size, there are problems associated with multiple plotters who must share the same workspace and squat or kneel to reach lower portions of the boards.² These problems were alleviated by providing increased workspace of 40" behind the main plotting board. A reconfiguration of the boards may further minimize the problem of shared workspace.

One considerable change to the present layout was a change in radio location. Two alternative radio layouts were provided; one with the radio placed beneath the table and the other in a separate storage cabinet. Since under-the-table placement of radios is uncommon and might prove impractical in operations, an alternative rack mounting was provided.

Following analyses of the M820 workspace and application of basic human factors design principles, a new workspace layout was designed. The major workspace layout consideration was the rotation of plotting boards and worktable (viewing position) by 90° in the plan view. This basic design should provide improved ingress/egress for plotters, allow optimal (but not unobstructed) viewing angles for the RT0, OIC, and the aviation operation specialist, and provide fixed placement of most layout components. It is recommended that workspace layout analyses and concepts such as those presented in this report be considered for ABMOC M820 shelters in order to provide an improved soldier-machine interface.

²Continual squatting or kneeling may cause fatigue and hence VanCott & Kinkade, 1972, recommend a 32-inch minimal dimension off the floor for upright charting surfaces.

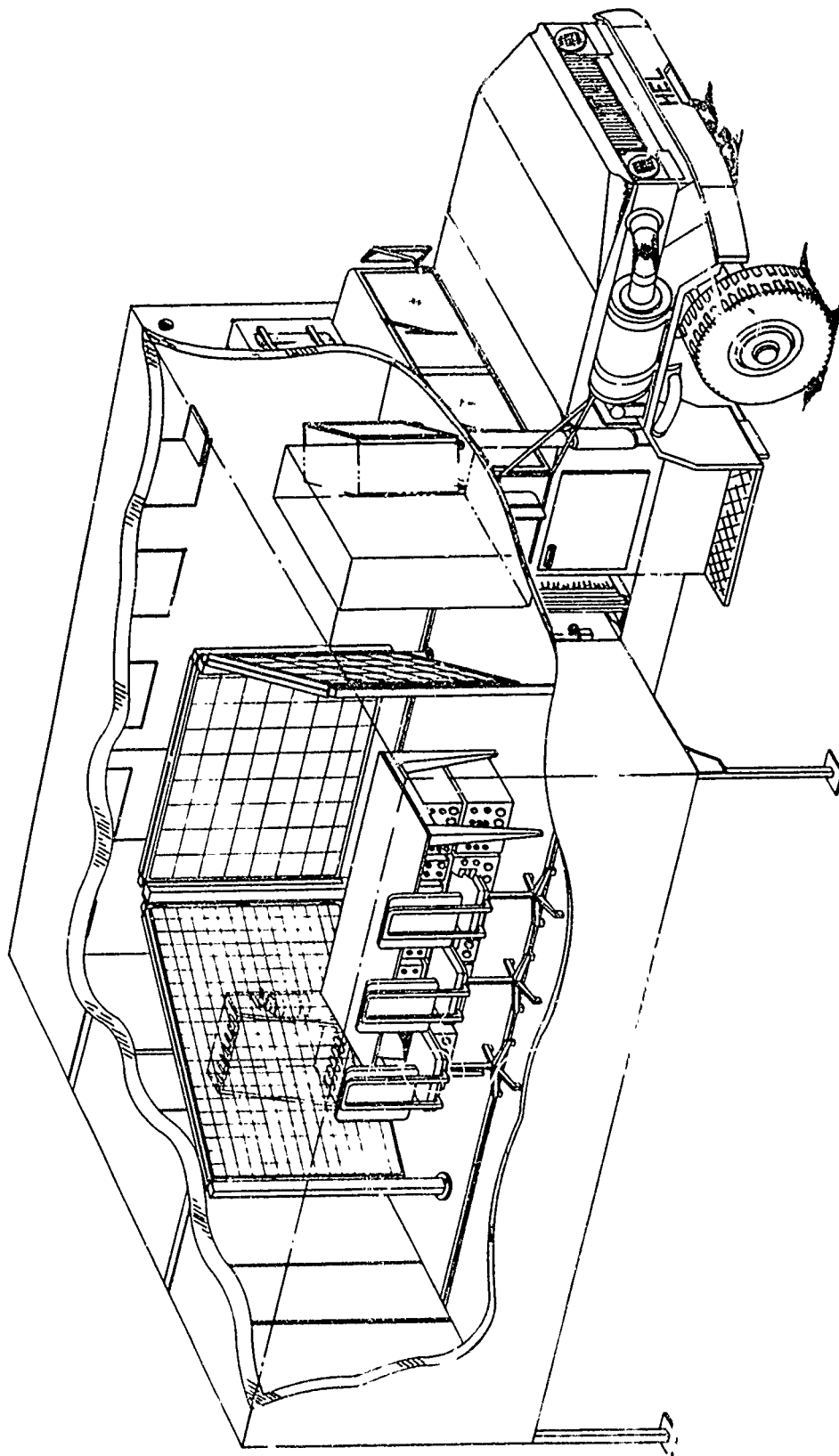


Figure 8. Expansible van (isometric cutaway view).

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APPENDIX A
PLOTING BOARD DRAWINGS

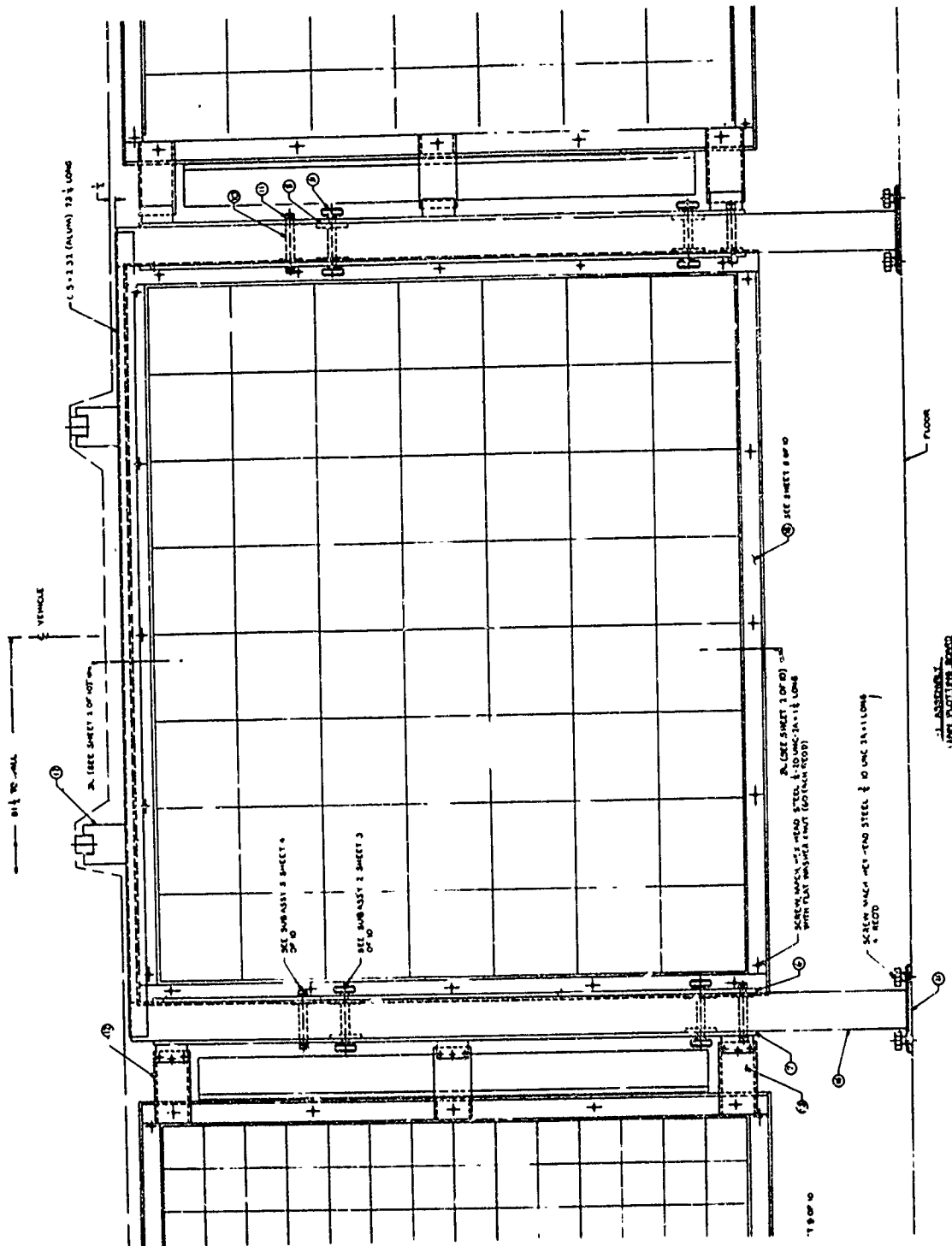


Figure 1a. Front assembly view of main plotting board.

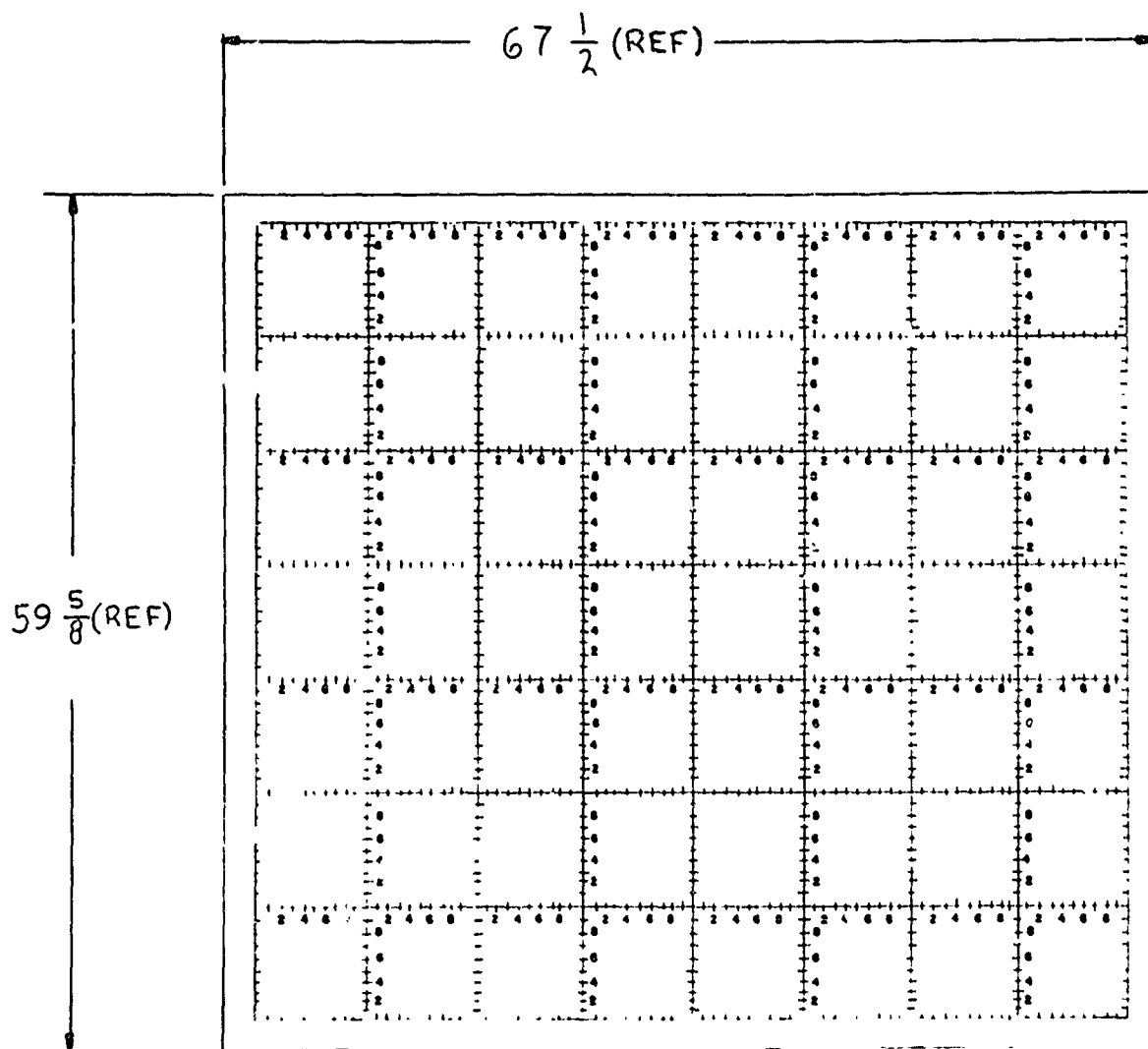


Figure 2a. Full view of main plotting board.